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ABSTRACT

A study of 159 students assigned to remedial algebra courses was initiated at Queensborough Community College to determine levels of improvement in algebraic skills and the effects of regular, programmed, and modular teaching methods. All students studied the same material with the following differences: (1) regular instruction used no programmed or modular techniques; (2) programmed sections used pre-testing to decide individual areas for study; and (3) module students were placed in one of four instructional levels according to pre-test scores, and completed from one to four modules. The Cooperative Math Test: Algebra 1, was used for placement/pre-test, and as a post-test after final class examinations. Mean scores of all sections increased from pre- to post-test; all increases were statistically significant. Analysis of covariance showed no statistical difference among means of the three instructional groups. However, modular and programmed methods required less student time for completion, although only in modular sections could students actually complete the course in three, six, or nine weeks. Sampling was dependent on teacher cooperation. Future research relating to all remedial sections is recommended. Mathematics requirements by curriculum are appended. (RT)

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A STUDY OF REMEDIAL ALGEBRA COURSES TAUGHT AT QUEENSBOROUGH COMMUNITY COLLEGE: SPRING AND FALL 1973

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A STUDY OF REMEDIAL ALGEBRA COURSES TAUGHT AT QUEENSBOROUGH COMMUNITY COLLEGE: SPRING AND FALL 1973

Abstract

For two consecutive semesters, students enrolled in a remedial elementary algebra course (MA-10) at Queensborough Community College were pretested and posttested using the Cooperative Mathematics Test: Algebra 1. In both semesters, statistically significant increases were found between the pretest and posttest means. A breakdown by three teaching methods (Regular, Programmed, and Module) did not reveal any statistically significant differences in posttest means. However, if the length of instructional time in MA-10 is considered, the modular system is superior to the Regular and Programmed methodologies because many Modular students complete MA-10 requirements in 3 to 9 weeks.

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A STUDY OF REMEDIAL ALGEBRA COURSES TAUGHT AT QUEENSBOROUGH COMMUNITY COLLEGE: SPRING AND FALL 1973

Introduction

Under the program of Open Admissions at the City University of New York (CUNY), all graduates of New York City high schools, without regard to high school average, are guaranteed entrance to a CUNY college. With the increased range of mathematical skills among students during Open Admissions the need for effective methods of remediation is heightened. Before the advent of Open Admissions, Queensborough Community College (QCC) required incoming freshmen to take a battery of placement tests in English and Mathematics. These tests are routinely administered to all students in order to enable the College to guide the student into the level of coursework most appropriate to his needs. The results on these placement tests determine whether students require remedial courses in English and Mathematics.

One major thrust of this study was to determine whether students designated by the Cooperative Mathematics Test, in Elementary Algebra to take remedial algebra (MA-10), improve their algebraic skills. The other major thrust was to determine whether there were differential effects for three different methods used to teach MA-10.

Purpose and Objectives of the Study

The present study was undertaken to investigate whether students enrolled in a remedial elementary algebra course (MA-10) show improvement in their knowledge of algebra after one semester's work. Specifically, two questions were asked:

1. Do students enrolled in MA-10 score higher on a measure of elementary algebra at the end of the semester compared to their scores at the beginning of the semester?
2. Is there a difference in performance at the end of the semester among MA-10 students enrolled in regular, programmed, and module format courses?

Description of the Courses

During the Spring and Fall 1973 semesters, three different kinds of MA-10 courses were taught. In addition to the conventional course, herein referred to as "regular," there were "module," and "programmed" courses. The general topics covered in all courses were: signed numbers, operations on fractions, equations, graphing, solving for unknowns, and formulas including those taught in geometry.

Mathematics instruction in all three methodologies was not confined to the classroom. The Mathematics Department

conducted a "math lab" where students who needed extensive help could come for additional tutoring. There were two types of tutoring available. In the first type there were two paid graduate assistants (doctoral candidates) who had regular hours in the math lab. Students were free to come at those hours for tutoring whenever they themselves felt they needed help.

In the second type of tutoring students who needed help on a continuous basis were assigned to paid QCC student tutors. The students had to be recommended by their classroom teacher for this service. In the latter, appointments were arranged and the students met their tutors on a regular basis. Students availed themselves of the services of the math lab regardless of the type of MA-10 course in which they were enrolled.

A brief description of the three methods of teaching now follows.

Regular

The regular or conventional method of teaching was a potpourri of teaching strategies. A survey of MA-10 teachers revealed that various teaching methods were used. These included lecturing, conducting discussions, and reviewing homework problems. Usually several methods were used in combination. The regular method however, did not utilize

programmed or modular techniques.

All classes used the same text, Elementary Algebra for College Students by Drooyan and Wooton (1972). The students remained intact in the regular course until the end of the term. In the programmed and module courses, the conventional procedures described above were modified.

Programmed

At the beginning of the term the students received a programmed textbook. During the terms being studied, the text was Basic Algebra (McHale & Witzke, 1971). The same concepts taught in the regular course were covered by the text but the teacher helped each student decide which topics to cover by administering teacher made tests at the beginning of the term. In this way, the programmed course differed from the regular course. If a student completed all his assigned topics early, he could leave the course before the end of the term. However, in reality, most students remained for the entire semester.

The programmed textbook presented an explanation on a given topic, worked out problems and gave corresponding exercises to the student, all in a step by step fashion. Each such textbook presentation was followed by a daily test. If the test was passed, the student went on to the next lesson. If the student did not answer the questions correctly, the

text recycled him back to re-study the material.

The students came to class every day and worked individually on their assignment. The teacher graded the daily tests, advised the students on whether to continue or review and was available for questions.

Module

There were four modules which progressed from elementary topics in algebra to more difficult mathematical concepts. In total, the four modules represented the same syllabus taught in the regular and programmed course. The major difference between the module course and the other methods was that the curriculum consisted of four separate sections.

At the beginning of the term, four or five MA-10 sections were simultaneously scheduled with students registering in the modules randomly. All students were tested to determine their elementary algebra level by a diagnostic-type test specially constructed by Module teachers. Based on the results of this test the teachers internally shifted the students around to create relatively homogeneous module classes. Depending on a student's starting level, (skill mastery), he or she had to take anywhere from one to four modules. Each module lasted three weeks and a student moved on to the next module only when he or she had shown satisfactory performance on the final test of the module. The passing grade was 70%

and approximately 80% of the students satisfactorily completed each module. The students who did not pass were required to repeat the module.

Within any module the content was similar to that of the regular or programmed courses. The text used was the same as for the regular classes. Material was appropriately selected for each Module.

Placement Procedure for MA-10

In the spring and fall of 1973, Basic Mathematical Skills, (MA-10) was a non-credit course taught at QCC which met for 5 hours a week. The content covered beginning algebra and some elementary concepts from geometry. Students were placed into MA-10 on the basis of their scores on the (CMT) Cooperative Math Test: Algebra 1 (a 40 item test) published by Educational Testing Service, Princeton, N.J. (1962).

Students in all curricula at QCC, except Nursing Science, were required to take at least one non-remedial credit bearing math course. For each such math course there were two placement tests which the students were required to take in order to determine their readiness for the math course required by their curriculum. (See Appendix A for a listing of QCC's curricula with the associated required math course and required math placement tests). Whenever the skills taught in MA-10 were prerequisite to entering a course, the

students were required to take the Algebra 1 test.

The Cooperative Mathematics Tests Handbook (1964) cites national urban norms for grade 9. A raw score of 20 is equivalent to the 47th percentile for all urban students in grade nine. No data were cited for college freshmen. For all students, except Liberal Arts, a score below 20 on Algebra 1 placed them into MA-10. The score represents the number of items the students answered correctly. Incorrect or non-answered items do not affect the score. For Liberal Arts students, a score below 10 or 15 (depending on which math course they planned to take) placed them into MA-10 (8th percentile). It should be noted that the cutoffs had been raised since the time of this study. Beginning with Fall 1975 entrants, the Omnibus Math Placement Test (constructed by members of the QCC Math Department) is used as a screening instrument for incoming freshmen.

Description of the Instrument

The CMT Algebra 1 test form used at QCC published by Educational Testing Service (ETS), was developed and normed in 1962. There has been no subsequent revision.

The test consists of 40 multiple choice items with five choices per item. The standard time allotted is 40 minutes. A machine readable answer sheet was used to record the answers.

Reliability

According to the Cooperative Mathematics Test Handbook (1964) the Kuder-Richardson (KR-20) internal consistancy reliability of the Algebra 1 test is .86. However, the sample of the 8th and 9th graders used was quite heterogenous and this reliability would therefore be an overestimate. It should be pointed out that K-R 20 could be an overestimate if the test is speeded. However, according to the Handbook, a large enough proportion of the 8th and 9th graders in the norming group finished the Algebra 1 test even though it is a timed test. Observations of tests taken at QCC confirmed this fact for our own students. Therefore, for QCC students, the Algebra 1 test is a power test and would not be considered speeded. Bearing this in mind, the K-R 20 reliability of the Algebra 1 test was computed. The reliability for a sample which consisted of all QCC students enrolled in MA-10 during the Spring of 1973 was 0.89 (N=407). This reliability coefficient is quite high and it should be noted that if the reliability analyses was based on a sample of all students not just those scoring between 0 and 20, the reliability would be the same or higher.

Validity

The validity of a test is the extent to which a test measures what it purports to measure. One aspect of validity

is content validity. In this case experts judge the items of a test to determine the extent to which the content of the test is congruent to what is being taught in the classroom. According to the CMT Handbook a large number of Mathematics teachers were involved in deciding whether the items were valid. The final form of the tests represents the experts' consensus that the test has content validity. The handbook, however, does recommend that individual users of the test make their own determination as to whether the test is relevant to the specific course being taught. Various members of the QCC Mathematics Department have voiced their opinion that the Algebra 1 test does not adequately measure the achievement of cognitive objectives in the MA-10 classroom. However, the Math Department has not conducted a formal content validation study.

Other aspects of CMT test validity such as criterion-related validity have not been reported in the literature.

Data Collection

The CMT placement test routinely administered to all incoming freshmen was used as a pretest. Each semester after final examinations were administered, students were post-tested with the same instrument. All the completed tests were sent to the QCC Data Processing Center for scoring and placement.

The subjects in this study were enrolled in MA-10 during the fall and spring '73 semesters. Students with scores below 20 on the CMT Algebra 1 placement test were required to take MA-10 before taking regular credit bearing math courses in their curriculum. (See Appendix A.)

Missing Data

All MA-10 teachers were requested to posttest their students, however, not all complied. In addition, students in the modular system who completed their modules before the end of the semester were not posttested.

During the spring semester, of 426 students enrolled in MA-10 courses during the day, a total of 159 students took the posttest. Table 1a shows the breakdown by treatment of the students included in the study for Spring '73. The percentages in the last column are based on all students enrolled in MA-10 regardless of whether the students' class was included in the study or not. Therefore, these percentages include those students whose teachers did not participate in the study and those students who were absent from or who had withdrawn from the courses of those teachers who did participate in the study.

Table 1b shows the percent of students in the study based only on the number of students in the courses whose teachers participated in the study. This percent represents the attrition due to absence during posttesting and also withdrawals

from the course. As can be seen in the last column of Table 1b the attrition rate is about the same for the three treatment groups. For the Spring '73 semester 159 students (42.6%) were posttested out of 373 who were pretested.

Table 1a

Number and Percent of Classes and Students Included in Study Based Upon Total Enrollment of MA-10 Classes Spring - 1973

Treatment	No. of Sections Taught	No. of Sections in Study	% of Sections in Study	No. of Students Enrolled in all Sections	No. of Students in Study	% of Students in Study Based on Total # Enrolled
Regular	12	10	83.3	226	82	36.3
Programmed	5	5	100.0	103	42	40.8
Module	5	4	80.0	97	35	36.1
Total	22	19	86.4	426	159	37.3

Table 1b

Number and Percent of Students Included in Study Based Upon the Number of Students in Included Sections - Spring 1973

Treatment	No. of Students in Included Sections in Study	No. of Students in Study	% of Students in Study Based on Students in Included Sections in Study
Regular	189	82	43.4
Programmed	103	42	40.8
Module	81	35	43.2
Total	373	159	42.6

Table 2a shows the breakdown by treatment of students included in the study for Fall '73 based upon total enrollment in MA-10. Table 2b shows data parallel to table 1b. As can be seen in the last column of Table 2b the attrition rate is slightly lower for the module group than the regular or programmed groups. It should be noted that in addition to any variables which evenly affect loss of subjects for the three treatment groups, the module group sustained an additional loss of data. Since the tests were administered at the end

of the term, students in the module courses who completed their required modules early were not captured during the posttesting.

Table 2a

Number and Percent of Classes and Students Included in Study Based Upon Total Enrollment of MA-10 Classes Fall - 1973

Treatment	No. of Sections Taught	No. of Sections in Study	% of Sections in Study	No. of Students Enrolled in all Sections	No. of Students in Study	% of Students in Study Based on Total # Enrolled
Regular	16	13	81.3	323	101	31.3
Programmed	6	2	33.3	135	17	12.6
Module	7	2	28.6	107	24	22.4
Total	29	17	58.6	565	142	25.1

For the Fall '73 semester, 142 students (40.8%) were posttested out of 348 who were pretested. (See table 2b)

Table 2b

Number and Percent of Students Included in Study
Based Upon the Number of Students in Included Sections
Fall 1973

Treatment	No. of Students in Included Sections in Study	No. of Students in Study	% of Students in Study Based on Students in Included Sections in Study
Regular	260	101	38.8
Programmed	44	17	38.6
Module	44	24	54.5
Total	348	142	40.8

During the Spring 1973 semester, 22 sections were taught by 19 teachers. (See Table 1a) Of these, 16 teachers who taught 19 sections participated in the study. During the Fall 1973 semester there were 22 teachers who taught 29 sections. Of these, 15 teachers who taught 17 sections participated in the study. (See Table 2a)

Limitations of the Study

Any conclusions drawn from this study are generalizable only to students enrolled in MA-10 courses at QCC. In ad-

dition, since there was a substantial amount of missing posttest data and since the sample was not truly random, caution should be exercised in generalizing the results.

Results

The means and standard deviations for the pre and posttests for the three treatment groups of MA-10 courses and the associated t-values for the differences between the pre and posttests are presented in Table 3 for Spring and Fall 1973 semesters.

Table 3

Means and Standard Deviations of Algebra 1 Pre and Posttest Scores for MA-10 Courses

	SPRING 1973						FALL 1973					
		Pre		Post				Pre		Post		
Treatment	n	Mean	sd	Mean	sd	t	n	Mean	sd	Mean	sd	t
Regular	82	13.01	4.29	19.16	5.01	10.55*	101	10.82	6.53	20.34	6.92	12.08*
Programmed	42	9.79	3.90	16.17	6.40	6.55*	17	10.29	6.03	21.82	7.77	6.71*
Module	35	11.69	4.43	19.34	5.26	9.23*	24	10.96	5.91	21.46	5.24	7.58*
Total	159	11.87	4.43	18.40	5.63	15.01*	142	10.78	6.38	20.70	6.80	15.51*

*$p < 0.05$

As can be seen in Table 3, in every case, the means increased from the pre to the posttests. In all cases the increases were statistically significant.

An analysis of covariance was performed on the posttest means to see if the differences between the three treatment groups were significant. An analysis of covariance statistical procedure is appropriate for use with "intact" groups where students are not randomly assigned to the treatment categories. This technique permits the researcher to statistically equate the groups with respect to a variable relevant to the dependent variable. In this study, the pretest scores served as the covariate to achieve statistical control of possible group differences. For the spring and fall 1973 data, the differences were not significant. Tables 4 and 5 present the results of the covariance analyses for the Spring semester.

Table 4

Analysis of Covariance of Algebra 1 Posttest Scores for Spring 1973 Using Algebra 1 Pretest Scores as the Covariate

Source	ss	df	ms	F
Treatment	94.29	2	47.15	1.82 ns
Error	4022.82	155	25.95	
Total	4117.11	157		

ns= not signigicant at the .05 level.

Table 5

Posttest Means Before and After Adjustment
Spring, 1973

Treatment	Treatment Mean	Adjusted Mean
Regular	19.16	18.58
Programmed	16.17	17.22
Module	19.34	19.43

As can be seen in Table 4, an F of 1.82 is not significant for 2,155 df (alpha = 0.05). There is, therefore, no statistically significant difference among the means of the three treatment groups.

Tables 6 and 7 present the data from the analysis of covariance and the associated means for the Fall 1973 semester.

Table 6

Analysis of Covariance of Algebra 1 Posttest Scores for Fall 1973 Using Algebra 1 Pretest Scores as the Covariate

Source	ss	df	ms	F
Treatment	54.70	2	27.35	0.65 ns
Error	5773.18	138	41.83	
Total	5827.88	140		

ns = not significant at the .05 level.

Table 7

Posttest Means Before and After Adjustment
Fall, 1973

Treatment	Treatment Mean	Adjusted Mean
Regular	20.34	20.32
Programmed	21.82	22.00
Module	21.46	21.39

As can be seen in Table 6, the F of 0.65 is not significant at 2,138 df (alpha = 0.05). There is, therefore no statistically significant difference among the means of the three treatment groups.

Discussion

As was seen in Table 3, the mean scores of the Algebra 1 test increased between pre and posttesting in all cases. The range of increases was from 6.15 to 11.53. In all 6 cases, the increases were statistically significant.

If the increases are meaningful it is yet to be determined whether the students have in fact removed their deficiencies in mathematics and of elementary algebra in particular. It should be noted that there are uncontrolled sources of invalidity which could possibly account for students ob-

taining higher scores on a posttest. The major ones are listed below.

1. When students are given placement tests at QCC it may be that they may not have taken a math course or test for several years. Elementary algebra is usually taught in the 9th grade. The low scores could possibly be due to students not being used to taking a math test and/or a loss of previously learned algebraic skills. Increases on the posttest could be due to the experience of taking the math placement tests. The test may of itself have been a learning activity.

2. Statistically, there is a phenomenon called regression towards the mean. If a test taker scores very high or very low on a test and takes the test a second time, his score will tend to be closer to the average or mean for all people taking the test. In other words, if a student scores very low on a test, the next time he takes the test he will usually score higher. This too could account for the students' scores increasing. In this sample, students with high scores were not assigned to remedial algebra (MA-10) and as a result their data could not balance the increase shown by low scoring students.

Of course, it should be considered that increases in Algebra 1 scores indicate that the students have indeed increased their knowledge of algebra. At the present time

however, it is difficult to rule out these possible explanations which attenuate the decisiveness of this study.

The analysis of covariance for each of the two semesters yielded no significant difference among the three treatment groups. The F's were 1.82 and 0.65 (with 2,155 and 2,138 df) respectively for the Spring and Fall semesters. This indicates that the methodology of teaching MA-10 does not seem to affect the Algebra 1 scores the student achieves at the end of the term.

However, the statistically non-significant differences among the three methods of teaching MA-10 may be viewed positively. When the variable of instructional time is considered, the Modular and Programmed methodologies seem to be superior to the Regular semester-long method of instruction since these students have the opportunity to spend less time in MA-10. In reality though, the Modular system seems most parsimonious since most students in the Programmed MA-10 system generally remain for the entire semester. In the Modular system however, many students require only 1, 2 or 3 modules and spend respectively only 3, 6 or 9 weeks in MA-10. Posttest data in this group however, was not available. It should be noted, though, that at the end of each module the student is required to pass a module final exam

which was of similar difficulty level as the posttest.

It should also be considered that the different treatments may have other effects not measured by the test. Persistance in the course, interest, attitude, and motivation in math learning may have been affected. These data were not collected. It should again be pointed out that students in the module courses who did well and left the course early were not posttested. It is possible that if these students' scores were included, the module course means may have been higher.

In summary, the data have shown that there were statistically significant increases between pretest and posttest scores. It must be pointed out that a statistically significant increase should not be interpreted to mean that students deficiencies in elementary algebra were in fact removed.

When comparing the posttest scores of the three methodologies of teaching MA-10, the Modular method appears to be superior to any of the others when instructional time is considered to be an important variable.

Future Studies

What is needed for a future study is to generate a control group of students who are required by the QCC Math Placement system to take MA-10 and then do not take

it. If these control students were tested after one or more semesters, these data could be used as a baseline for comparison with students who took the remedial math course. This would control for the effects of regression towards the mean. Persistence and math grades in subsequent courses could serve as criterion variables.

In addition, students leaving the module course early as well as the programmed course should be posttested before they leave. An effort should be made to secure participation of all MA-10 teachers and not just a sample (which may or may not be random) in order to rule out teacher differences as a source of variance. Additional independent variables can be added by administering attitude and interest scales to the students. If these variables are important mediators of achievement, their effect can be determined and separated from effects of the three teaching strategies.

It should also be determined whether the QCC procedure using the Mathematics Placement Tests, validly identifies students who truly need Mathematics remediation.

Future research should also include a comprehensive multiple regression analysis with math grades, GPI in math related courses, persistence, and graduation as criterion variables with the following as predictors or basic input variables:

1. Sex
2. Age
3. Curriculum
4. Experimental/Control
5. Other biographical data

This analysis will help to determine whether students who validly show academic deficiencies in mathematics and successfully complete remedial math courses, do better in regular credit bearing courses than students who show mathematics deficiencies and do not complete remedial courses.

An outcome of this analysis will also show whether sex, age, and other biographical data contribute to the effects of remedial instruction in math.

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APPENDIX A

Mathematics Course Requirements and Required Math Placement Tests as a Function of the Curriculum

CURRICULUM	REQUIRED MATHEMATICS COURSES	MATH PLACEMENT TESTS
Accounting or Management	MA-21	Arithmetic & Algebra 1
Business Transfer	MA 24 & 25	Algebra 1 & Algebra 11
Design Drafting	MA-17 & 18	Arithmetic & Algebra 1
Electrical (Computer) Electronic, or Mechanical Technology	MA-14,15 & 16	Arithmetic & Algebra 1
Liberal Arts (Non-Science & Non-Engineering Students) Student selects one or two courses	(MA-31 or 33	Arithmetic & Algebra 1
	(MA-32	" "
	(MA-34	" "
	(MA-36	" "
	(MA-40	Algebra 1 & Algebra 11
	(MA-41 or 42	Algebra 111 & Trigonometry
Liberal Arts Majors (Science)	MA-41 & 42	Algebra 111 & Trigonometry
Liberal Arts (Pre-Engineering)	MA-41	Algebra 111 & Trigonometry
Medical Lab Technology	MA-22,23 or College Algebra	Algebra 1 & Algebra 11
Nursing	None	Arithmetic
Non-Matric	-	Arithmetic & Algebra 1

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